ONR Tidal Flats DRI: Planning Joint Modeling and Field Exercises

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LONG-TERM GOAL

The ultimate goal of this work is to assist in the development of science plan for gaining a state-of-the-art understanding of macro-tidal, muddy estuarine/coastal environments through field experiments and modeling efforts. This is a challenging environment for a modeling framework, due to complexity of both the tidal currents and sediment erosion and deposition patterns. The morphologic modeling perspective has been our focus.

OBJECTIVES

The objective of the first phase of this work is the planning and development of joint modeling and field exercises, through attendance at and participation in the workshops hosted by the Office of Naval Research. Later phases will result in the potential development of a model of selected site(s), with validation and calibration facilitated by field program based on both *in-situ* and remotely sensed measurements. Battelle's specific participation was geared toward the circulation, transport and geomorphological modeling of these environments and incorporation of this perspective into the overall science plan. The use of models to help address the relative importance of tidal and river discharge to geomorphology has been identified as a key issue.

APPROACH

Future research efforts of project staff will likely be directed towards the application and evaluation of modeling tools and associated morphology and structures modules in the macro-tidal environment. With this in mind, development of a model for the original candidate site (Gyeonggi Bay, South Korea) was begun but the approach was designed to be easily adaptable to other sites and recent communications have indicted that there will be another sites chosen for pilot studies (Skagit Bay, WA and Willapa Bay, WA). Hibma *et al* (2003), Lesser *et al* (2004), Tonnon *et al* (2006), Van Duin *et al* (2004ab), Van Rijn (2007), and Van Rijn *et al* (2007a,b) reported on the development and application of the Delft geomorphology modeling tools for other sites. Past studies have shown that integration of

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observational programs and modeling are beneficial to both of these importance aspects of coastal studies similar to this DRI programs (Hibler *et al* 2007; Steinmaus *et al* 2006; Maxwell *et al* 2006; Maxwell *et al* 2007). Incorporation of near-shore and riverine structures such as dikes and weirs is also of interest, as these may have significant effects on flow and sedimentation patterns.

WORK COMPLETED

This work started in March, 2007. Within a month of initiation, the first DRI workshop was held in Honolulu, HI and Mr. Hibler attended that meeting. Mr. Hibler also attended the second meeting in Incheon, South Korea, in June, 2007, after developing a model mesh for the candidate site and performing some preliminary simulations with predicted tides as boundary forcing.

RESULTS

The demonstration model mesh developed for the Gyeonggi Bay site is shown in Figure 1, overlaid on Landsat imagery of the site using the Delft modeling tools. The mesh extends from the south of Incheon to the northern land boundary, and into the Han River estuary. Initial model meshes did not extend far enough up the Han River or southward; these initial meshes were shared the first DRI meeting in Honolulu, HI while the improved model mesh was presented at the second meeting in Incheon, South Korea. Most attention has been paid to tailoring the mesh to the shoreline in the Han River and Gyeonggi Bay region due to the programmatic focus in these portions of the system. A similar mesh could easily be configured for other sites of interest.

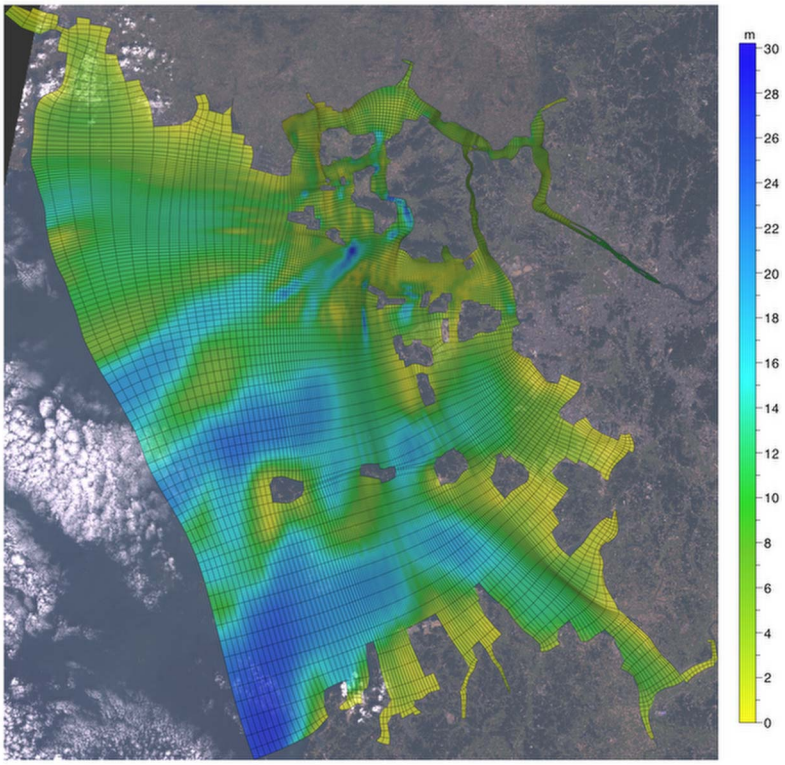

Figure 1. Model mesh for Gyeonggi Bay candidate site, overlaid on Landsat imagery.

Prior to the meeting in Incheon, the model was run with predicted tides for the month including the meeting. Preliminary results of a simulation with Delft-FLOW and morphology are shown in Figure 2 as deposition (red) and erosion (blue).

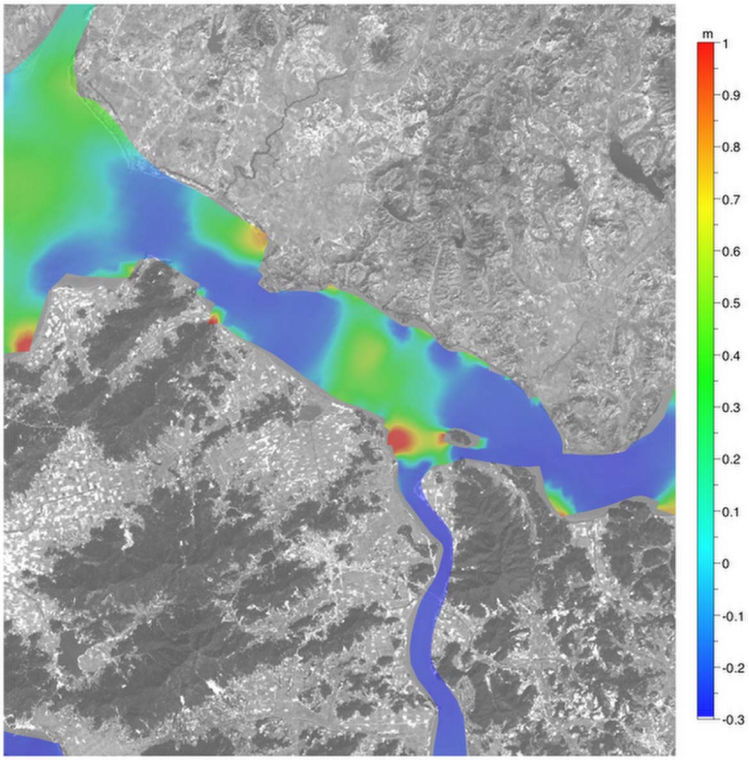

Figure 2. Erosion and deposition patterns after one month simulated time, at the northeast corner of Ganghwa Island in Gyeonggi Bay.

The model mesh used in development of Figure 2 did not cover the full extent shown in Figure 1, and sediment size and distribution are unverified. Initial bathymetric data used was from a digitized chart, dated 10 years previously. In spite of the preliminary nature of this figure, it is notable that deposition appears to be occurring in approximately the same areas as observed in more recent bathymetric and aerial surveys of this site.

Bathymetry used in this simulation is of fairly low resolution, and in some places of dubious quality. It is expected that higher resolution bathymetric datasets will be obtained during the field program, and the model can be improved incrementally with bathymetric data and density profiles.

Structures (dams, bridges) are in place in the channel of the Han River, and structures are also constructed along the shoreline near the Choji Bridge and other locations. Anecdotal evidence suggested that the bridge may have affected the sedimentation patterns on the tidal flat south of Ganghwa Island. Delft-FLOW has various structure representations, but it is not yet clear which are most applicable under these conditions. This remains to be evaluated as part of proposed future studies.

Other sites under consideration for this program (Skagit Bay and Willapa Bay, both located in Washington State) will most likely have better bathymetric datasets. For sites within the Puget Sound a

bathymetric dataset is available (Finlayson, 2005), and a subset of this is shown in Figure 3 for Skagit Bay. The Skagit Bay area includes submerged or partially submerged jetties, which may significantly influence currents and deposition patterns in the bay. The intertidal region is shaded orange in Figure 3, based on the range of mean lower low water and mean higher high water, relative to the available digital elevation model (approximately 9 meter horizontal resolution). A multispectral image of Willapa Bay is shown in Figure 4.

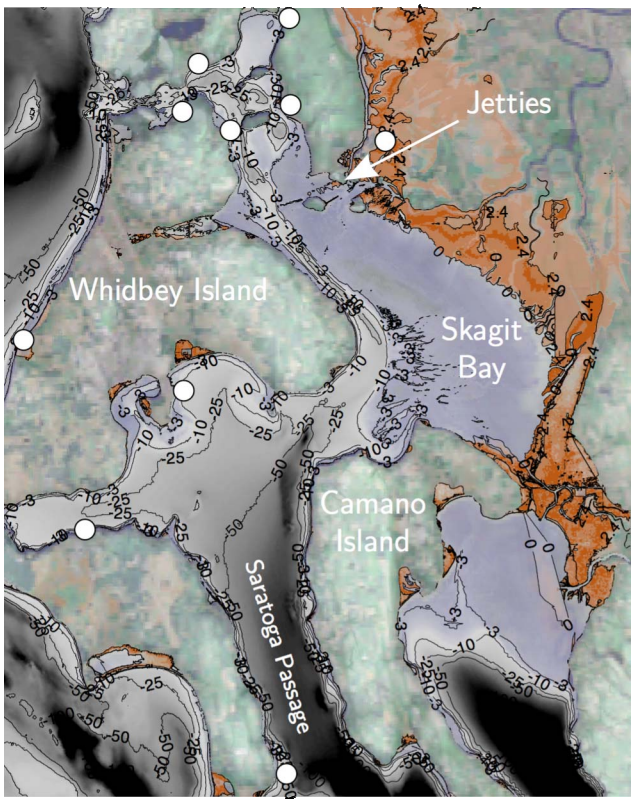

Figure 3. Skagit Bay and surrounding area. Intertidal region is shaded orange, and predicted tides are readily available for locations indicated with a white circle.

Figure 4. Multispectral image of Willapa Bay, showing tidal flat region.

IMPACT/APPLICATIONS

The demonstrated use of existing modeling software should both inform the community what can be expected under applied modeling scenarios as well as to point to areas were research and development efforts should be made. The integration of *in situ* and *ex situ* observations data sets is likely to improve the overall quality of the model and the model may then be used to focus additional field efforts. Examples of this approach are found in Hibler *et al* (2007), Maxwell *et al* (2007).

RELATED PROJECTS

ONR Coastal Environmental Effects Program, managed by T. Paluszkiewicz. Used Delft-3D in littoral environment, and collaborated with AUV and hyperspectral imagery collection and analysis (Hibler *et al*, 2007), (Steinmaus *et al*, 2006), (Maxwell *et al*., 2006), Maxwell *et al*, 2007).

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